

TRANS-GULF SPRING MIGRATION OF BIRDS AND THE COASTAL HIATUS *

BY GEORGE H. LOWERY, JR.

FORTY years ago Wells W. Cooke suggested that many birds which migrate across the Gulf of Mexico in spring do not stop on reaching the coast of the United States but instead fly some distance inland before alighting. Notwithstanding the importance of Cooke's brief but pointed statements (1904:13, and 1915:33), surprisingly little attention has been given the matter by subsequent writers. Cooke's original postulation was based on meager evidence supplied by a few scattered field observers; his later comments were apparently prompted by the knowledge that two competent ornithologists had spent an entire spring on the northwestern coast of Florida without finding a single example of many regular trans-Gulf migrants such as the Yellow-breasted Chat, Redstart, and Indigo Bunting. Since abundant data from the lower Mississippi River valley and from along the Gulf coast of the United States are now available for analysis, Cooke's postulate may well be re-examined.

To the many ornithologists who study migration of species that use the trans-Gulf flyway, and to those who think of the Mississippi delta as the region where myriads of weary transients immediately alight upon sight of land, the following statement may come as a surprise: During clear weather, trans-Gulf spring migrants that do not breed on the Gulf coast or in the lower Mississippi River valley proceed inland several hundred miles before coming down. That stretch of coast which one might suppose to be teeming day after day during the spring with multitudes of migrants which have just completed the over-water passage from Yucatan or Campeche is, in actuality, *during fine weather*, an "ornithological vacuum" so far as many migrants are concerned. Many species of common trans-Gulf migrants are rare or absent at certain coastal stations throughout an entire spring migration period. *During inclement weather*, however, all trans-Gulf migrants are precipitated on the first available land, and this results in enormous concentrations of migrants on wooded coastal islands and cheniers.¹ When the weather clears, most migrants immediately resume their northward flight.

* Since some readers may be surprised that Mr. Lowery makes no reference here to George G. Williams' very stimulating article on trans-Gulf migration that appeared in the January 1945 *Auk*, it seems desirable to explain that the present paper was submitted to the *Bulletin* in May 1944, and technical difficulties have delayed its publication until now. It is interesting to compare the data presented by Williams with that assembled by Lowery and to note their very different conclusions.

Mr. Lowery now informs me that he made in May of this year a very interesting trip on a slow boat to Progreso, Yucatan, and gathered important additional evidence of trans-Gulf migration. This, with new migration data collected along the coast, on the Gulf, and in Yucatan, by boat crews and others he has interested in the problem, will be included in a report he is now preparing for the press.—Ed.

Some writers have gone so far as to assert that the state of the weather at any point has little, if anything, to do with the arrival of migrating birds, and the belief of observers who have thought that they could foretell the appearance of various species by a study of weather conditions has received little or no support. Nevertheless, the state of the weather in the lower Mississippi valley and along the Gulf coast is of tremendous importance in determining the arrival of migratory species at any given place in those areas, and will, therefore, be given detailed consideration in the present discussion.

EFFECTS OF POLAR FRONTS

Inclement weather on the northern Gulf coast in the spring most frequently results from the movement of cold polar air-masses down from the north or northwest and their subsequent contact with warm air that is approaching from the south. Advances of such cold air masses are usually described in Louisiana as "northers" or "northwesters." Along the forward edge (the polar front), the warm and humid air is

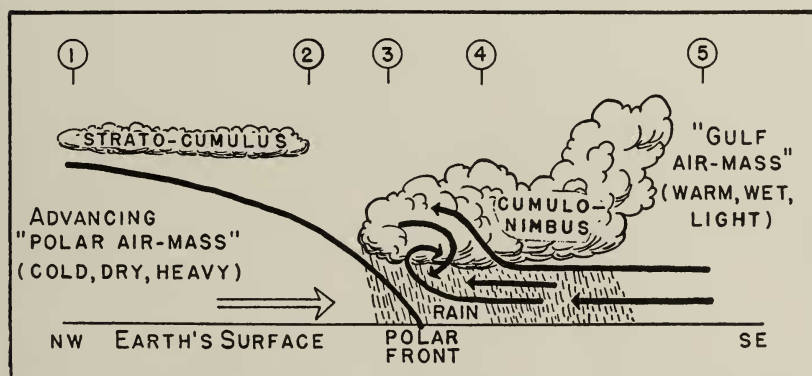


Figure 1. Idealized vertical section in atmosphere showing conditions associated with an advancing polar front. The scale varies with individual fronts; the above might represent a distance of 100 miles horizontally and 10 miles vertically. The rate of advance varies from 5, or 10, to 60 miles per hour. Point 1 lies in polar air; light to medium northerly or northwesterly winds and dry air are typical here. Point 5 lies in warm, humid Gulf air. Point 4 has heavy cloud cover, precipitation, and violent, gusty winds. Electrical storms are typical along this "squall line." Higher and thinner clouds, with less precipitation, characterize Points 2 and 3. At Point 2 there may be only a high cirrus haze.

forced to rise as a result of being under-run by an increasingly thick wedge of cold air. Under the decreased pressure at higher levels the warm air expands and cools. Condensation and precipitation result. At

¹ In coastal Louisiana a *chenier* is a wooded ridge running through the low marshes parallel to the Gulf.

the edge of the cold front the forced ascent of warm, moist air is violent and intermittent, and is accompanied by squally winds, not infrequently by rather severe twisters. The clouds are of the cumulo-nimbus type (Rossby, 1941:634).

What happens when birds crossing the Gulf of Mexico through the warm air-masses lying over the whole Gulf-Caribbean region encounter the forward edge of air masses descending from the north (see Figures 1 and 2), with the accompanying headwinds, squalls, and generally

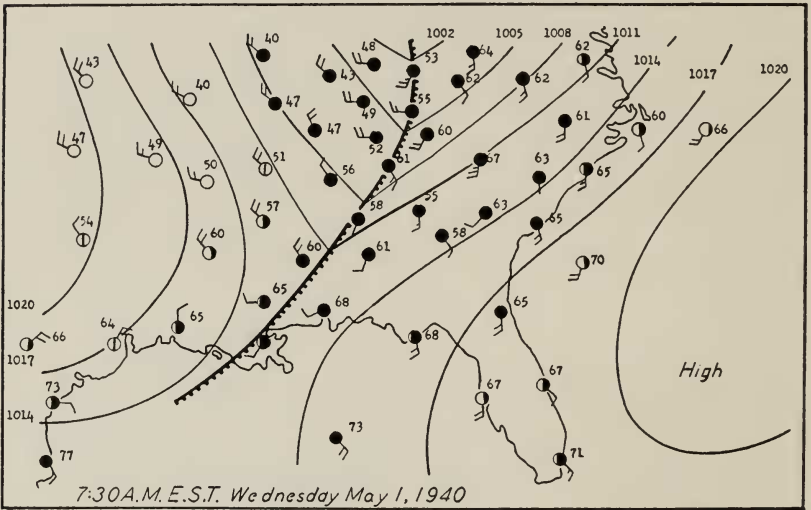
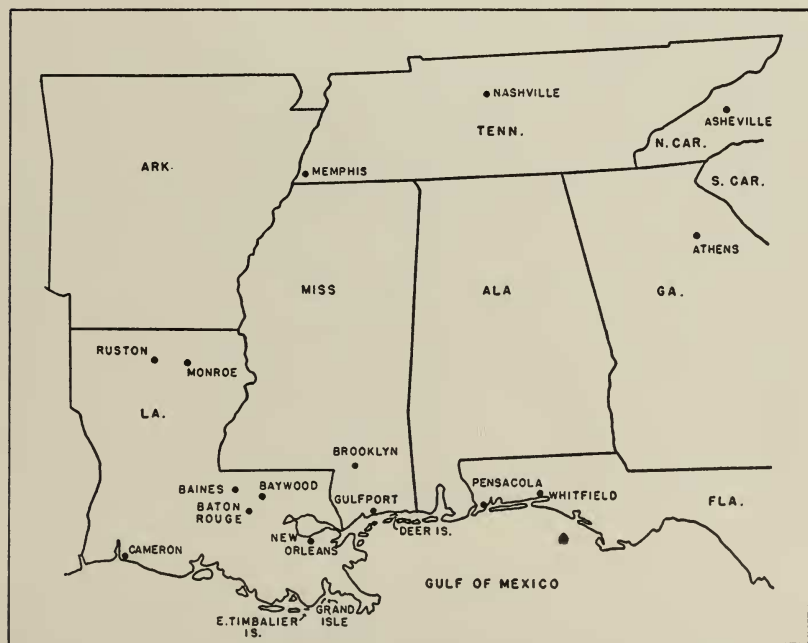


Figure 2. Position of a polar-front wave over the southern United States on May 1, 1940 (from Rossby, after Haynes). The cold front is indicated by the barbed line; the warm front (over the northern states) is not shown. The eastern part of the country lies in warm, humid air, the western part in cold, dry air. This may be seen by the temperatures (in °F.) at each station. The direction toward which the wind is blowing is shown by the arrows pointing to the circles representing the stations. Wind velocity is indicated by the cross-bars on the arrows, one full bar denoting approximately 5 miles per hour. The degree of cloudiness is indicated by the extent to which the station ring is filled with black. Figures on solid lines show pressure in millibars.

stormy conditions, will be discussed in detail later, but it is obvious that when the polar front extends southward beyond the northern edge of the Gulf, migrants must turn back to Yucatan or try to reach the land ahead, either by flying through the storm or by ascending above it. To fly above the storm would be possible for only a short distance. The height of a cold front, even comparatively near its forward edge, doubtless exceeds the upper flight limit of most (if not of all) migrants. That migrants would under any circumstances retreat to the point of their departure, especially after having covered more than half the dis-

tance across the Gulf, is supported neither by evidence nor by logic. Various observations show that when migrants reach the "squall area" just ahead of the polar front they drop close to the surface of the Gulf, possibly in an attempt to escape the buffeting effects of higher wind currents, and then exert their full energies toward beating their way through the headwinds and squalls to the shelter of land.

Frazar (1881) describes the efforts of many small birds to reach shore against a severe "norther" on the afternoon of April 22, 1881,² 30 miles off the coast of Louisiana. On numerous occasions I have witnessed similar phenomena. On April 7, 1937, I found almost no migrants on Grand Isle, Louisiana, a small narrow island 40 miles west of the mouth of the Mississippi River (Figures 3 and 4, Map 1). On April



Map 1. The northern Gulf coast.

8 a strong "norther" developed. At 2:00 P.M. we stood on the front beach and observed several small flocks of Purple Martins (*Progne subis*) and Eastern Kingbirds (*Tyrannus tyrannus*) appear from over the Gulf flying very low. These birds immediately settled in the trees

² Frazar's article gives the date as April 2, but this may have been a typographical error. Cooke (1904:25) refers to the same observation under the date April 22, probably from notes furnished him directly by Frazar. Certain birds mentioned by Frazar are definitely the kinds which he might have encountered late in April and not ones which appear so early as the first part of that month.

just behind the front beach. Later in the afternoon we saw a larger bird approach the island and followed it with binoculars until it came to rest within a short distance of us on the beach. We identified it as a Green Heron (*Butorides virescens*). The bird was obviously fatigued and we nearly succeeded in catching it before it struggled ahead of us a few feet to the safety of the near-by trees. All during the afternoon of April 8, birds continued to appear in great numbers in the trees on the island. The morning of April 9 was particularly notable for the great abundance of Cerulean Warblers (*Dendroica cerulea*), which are rather rare spring transients on the Louisiana Gulf coast. The trees were literally filled with this and other species of birds.

Incoming migrants that are attempting to reach land in the face of a storm are not always fortunate enough to make contact with the coast at points where wooded areas provide refuge from the wind and rain. In Louisiana, particularly, there are vast stretches of coastal marshes, sometimes 40 to 50 miles in depth, in which transients would find little shelter from the elements. That storm-battered migrants do, nevertheless, take refuge in such barren areas is evident from numerous observations. In April, 1940, for example, I had planned to cross Timbalier Bay from the mainland to East Timbalier Island. But my companions and I were detained at the mouth of a small canal emptying into the Bay by a "norther" which came up on the night of April 11. Because of the high winds, our boat was tied up on the edge of the marsh throughout April 12. We went ashore and found the short marsh grass and low-growing mangrove bushes teeming with small birds, notably Acadian Flycatchers, Red-eyed Vireos, Cerulean, Yellow, and Kentucky Warblers, American Redstarts, and Orchard Orioles (*Empidonax virescens*, *Vireo olivaceus*, *Dendroica cerulea*, *Dendroica aestiva*, *Oporornis formosus*, *Setophaga ruticilla*, and *Icterus spurius*). They were feeding energetically in the low growth and apparently working in a general northerly direction.

Islands and cheniers along the coast, on occasions such as just described, may be literally flooded with small migrants. No printed description can possibly convey a full appreciation of the sight. The bird observer is often bewildered by the number of birds on mornings following the advent of a "norther." On several occasions, Grand Isle, Louisiana, has been the refuge of such great hordes of incoming migrants that practically every bush on the island contained birds. Warblers have been observed perching on the porches of houses and fluttering in numbers through open windows; they have presented such concentrations that an observer could stand in one spot and count a hundred or more small birds close at hand.

Thomas D. Burleigh (*in litt.*) describes a similar observation made on Deer Island, on the coast of Mississippi, on April 26, 1940. He noted 20 species of warblers alone, and the number of individuals of all migrant species ran into the thousands. This was preceded and accom-



Fonville Winans

Figure 3. Aerial view of Grand Isle, Louisiana. In the foreground, the Gulf of Mexico; in the background, Barataria Bay. The island is about nine miles in length, but only the central part is covered with vegetation as shown here.



Fonville Winans

Figure 4. Close-up of vegetation on Grand Isle, taken near the center of the area shown in Figure 3. It is isolated areas of shelter such as this that frequently serve as refuges to swarms of migrants arriving on the northern Gulf coast during adverse weather.

panied by the advance of a polar front that extended over part of the Gulf of Mexico. (See Table 5.)

Many incidents similar to those just described, illustrating the kind of weather prerequisite to the appearance of great waves of trans-Gulf migrants in Gulf coast regions, could be drawn from my notes and those of other recent observers.

DEPARTURE OF BIRDS FOLLOWING POLAR-FRONT STORMS

The weather immediately following polar-front storms in the Gulf coast region is usually characterized by clearing skies and rising temperatures. Winds generally shift back to the south or southeast a few days after the arrival of a cold front.

Contrary to opinions expressed by some writers, migrants which arrive on the Gulf coast are not so completely fatigued as to require long periods of rest before advancing northward. Flocks of migrants which seem to remain in one locality for several days probably represent several successive waves. Burleigh, at Gulfport, Mississippi, and Weston, at Pensacola, Florida, concur (*in litt.*) in the assertion that as the weather clears following a "norther" the swarms of migrants immediately begin to disappear. Should the weather clear on the morning following the passage of a polar front, the concentrations are usually maintained throughout the first day. On the second day, however, only a few are found, and even those may be individuals composing the rear-guard of the initial flight which did not reach shore until sometime during the preceding day.

Of course many observations support these statements and analyses but the events of March 27-29, 1942 are especially typical and conclusive. Thomas R. Howell and I reached Grand Isle, Louisiana, in the late afternoon of March 27. The wind was out of the north, and the sky was heavily overcast. Although the western end of the island consists chiefly of sand dunes, marshes, and mud flats, one of the several small birds we found feeding on the treeless sand dunes by the side of the road was a Yellow-throated Warbler (*Dendroica dominica*). An arboreal species such as this feeding among sand dunes or other treeless places is a characteristic occurrence when migrants are forced by the weather to descend on the first available land.

We made a brief survey of the wooded section of the island before nightfall. Trees and bushes were filled with birds. The wind grew stronger near midnight. Early on the morning of March 28 we began a systematic inspection of the bird life in a stretch of live oaks about three-quarters of a mile long and 200 yards wide. The number of birds present was incalculable. Throughout the day we worked slowly back and forth through this woodland. There was an amazing number of small migrants; standing in any one spot, we could easily count several hundred birds within view. The predominant species were the White-eyed Vireo and the Black and White, Prothonotary, Parula, and Hooded

Warblers. The earliest Louisiana arrival dates for four species—Cerulean and Blackburnian Warblers (*Dendroica fusca*), Oven-bird (*Seiurus aurocapillus*), and Redstart—were established on March 27 or 28, a point which will serve to illustrate subsequent discussions under the heading of "Average Arrival Dates."

The weather cleared completely on March 28, and the temperature rose rapidly throughout the day. On March 29, after a completely clear night with moderate easterly winds, only a few birds could be found, proving beyond any question that most of them had resumed their flight during the first night following the abatement of the storm. (See Tables 1 and 6.)

TABLE 1

COMPARISON IN NUMBER OF INDIVIDUALS OF CERTAIN MIGRANTS SEEN AT GRAND ISLE, LOUISIANA, ON TWO SUCCESSIVE DATES

	March 28	March 29
White-eyed Vireo, <i>Vireo griseus</i>	100	6
Yellow-throated Vireo, <i>Vireo flavifrons</i>	10	3
Black and White Warbler, <i>Mniotilta varia</i>	300	30
Prothonotary Warbler, <i>Protonotaria citrea</i>	300	30
Parula Warbler, <i>Compsothlypis americana</i>	300	30
Yellow-throated Warbler, <i>Dendroica dominica</i>	25	0
Louisiana Water-thrush, <i>Seiurus motacilla</i>	8	1
Kentucky Warbler, <i>Oporornis formosus</i>	25	3
Hooded Warbler, <i>Wilsonia citrina</i>	200	35

Francis M. Weston, in a recent letter to me, stated: "You may be interested in an observation that extends your statement . . . about the resumption of northward flight after a period of bad weather. I have seen on at least two occasions the behavior of swarms of delayed migrants on the last day of their enforced stop-over. Each time the weather was clear and mild, with no wind. Toward sunset, the birds congregated in the tops of the tallest trees, where the last rays of the sun made them very conspicuous. I have never seen so many Summer Tanagers and Orchard Orioles as on these two occasions. From the tops of the trees, small groups occasionally made short flights upward, returning to the trees. They continued to do this as long as the light lasted and I could see them and, presumably, they continued to do this even after dark until the electric moment for departure arrived, for in the morning they were gone and the woods were deserted."

Burleigh, who has made observations on the Mississippi coastal islands over a period of eight years, informs me (*in litt.*) that his experiences have been similar. That is, when the weather clears following the passage of a polar front, migrants immediately begin to disappear from the coastal areas, indicating resumption of northward flight. Transient

migrants remain on the coast only so long as disturbed weather conditions and strong north winds continue.³

The correlation between local weather conditions and the appearance of trans-Gulf migrants has so far been considered only for the times when polar fronts extend to or even beyond the Gulf coast. Often the polar air masses do not reach the Gulf before losing their forward momentum. The weather along the coast may be highly inclement with overcast skies and fresh winds, but when the winds do not shift to the north or northwest, there is but slight precipitation of trans-Gulf migrants in coastal areas. In other words, most of the birds pass over the coastal region and are precipitated when the actual front is reached.

An analysis of a specific set of observations might serve to illustrate the point in question. George M. Sutton, James H. Bruns, and I arrived on the coast of Cameron Parish in the late afternoon of April 21, 1942. We spent the following week in studying the bird life of the region, particularly that found on the island-like oak ridges or cheniers paralleling the coast. The weather conditions during the period were for the most part unsettled with occasional rains, but at no time did a "norther" develop. There were practically no migrants, except for the small number present on our arrival. Inquiry among residents at the time, and a check later with Weather Bureau reports, indicated that we had arrived too late. A "norther" had developed a few days prior to our arrival; hence, the migrants present during the initial part of the period of observation were a carry-over.

Although the unsettled weather continued, no new cold fronts developed. Fresh winds blew out of the south, southeast, and east, but never from the north or northwest. Notwithstanding our location in the path of trans-Gulf migration at the height of the migration period, we found only negligible numbers of trans-Gulf migrants. It must follow that they were passing over the coast at that point. Several times during the day of April 27, the low-flying clouds broke overhead, and clear, blue sky was visible beyond. Since the unfavorable weather phenomena were occurring especially close to the earth's surface, there is not much doubt that the birds were flying above the adverse forces. Actually, weather conditions at those heights might even expedite northward flight. But as already stated, the distance that the birds could progress northward above the adverse weather conditions would depend on where the height of the squall area or the actual polar front exceeded that to which birds could ascend. When that threshold was reached, the birds would be forced to descend. Since successive waves of migrants would be precipitated in the same general area, a tremendous concentration of migrants would result there.

³ The Veery (*Hylocichla fuscescens*) and the Olive-backed and Gray-cheeked Thrushes (*H. ustulata* and *H. minima*) do sometimes linger longer than other birds because of the attraction afforded by the fruit of the red mulberry (*Morus rubra*) of which they are very fond and which is very prevalent in the coastal plain region.

If we had any method of determining the altitudinal limits to which birds might ascend before being forced to face the vicissitudes of the inclement weather below, we might, by study of weather charts plotting the movements of air masses, actually predict the areas where great concentrations of migrants could be expected in the lower Mississippi valley.

THE BATON ROUGE REGION

I first became aware of phenomena that suggested an extensive coastal hiatus before reading Cooke's brief remarks on the subject. I had spent several years observing bird migration in extreme northern Louisiana, at Monroe and Ruston. Since 1932, when I established residence at Baton Rouge, in south-central Louisiana, I have had the opportunity to make observations both there and in extreme southern Louisiana and to compare the patterns of spring migration on the coast, in northern Louisiana, and at Baton Rouge.

The Baton Rouge region is probably one of the best worked areas in the South if the number of field observers, the amount of time spent in the field, the large number of extralimital species collected, and the total number of species and subspecies recorded are accepted as criteria for evaluating the intensity with which a given area has been worked.

Baton Rouge is located on the banks of the Mississippi River almost directly in line with the center of the trans-Gulf flyway. In one direction the coast lies less than 70 miles away. The physiography of the country surrounding Baton Rouge is extremely diversified and should be attractive to birds. North of Baton Rouge are hills cut deep by ravines and forested with dense stands of mixed hardwoods, including holly, beech, magnolia, and several kinds of oaks; to the west, across the river, lies the extensive Atchafalaya River swamp with hundreds of square miles of mixed bottomland hardwoods and cypress; to the east, stretch equally large expanses of long-leaf, loblolly, and slash pines; and below the University, the battures⁴ of the Mississippi River are lined with cottonwood, willow, red gum, and sycamore.

Yet in spite of the location and apparent physical attractiveness of the Baton Rouge environs, and in spite of the thoroughness with which the area is worked, most of the trans-Gulf migrants that do not breed on the Gulf coast or in the lower Mississippi valley have been recorded rarely or not at all in the Baton Rouge region during the spring (see Table 2). The comparatively few records for those species which have actually been noted at least once in the Baton Rouge area are in virtually every case directly attributable to prolonged periods of inclement weather which caused an accumulation of migrants in the coastal region.

⁴ A *batture*, in current usage, is the area between the levee and the channel of the stream. Originally, before the building of the levees, the term was used to designate the high ground next to the channel. Sometimes considerable land lies between the levee and the river, especially where the levee does not follow the meanders of the river channel.

Observations recorded on April 30 and May 1-3, 1940, are notably significant in this connection. (See Table 5.) The latter part of April was decidedly unsettled throughout most of the central Gulf coast region. Burleigh (*in litt.*) recorded a great wave of migrants on the Mississippi coast on April 26. It was stormy at Baton Rouge on the night of April 29, and 2.44 inches of rain fell. The weather on April 30 was very unsettled, and we obtained the first Baton Rouge spring record for the Chestnut-sided Warbler. May 1 (see Figure 2) was cloudy in the forenoon with light rains, but the skies had cleared by 11:30 A.M. The woodlands 15 miles north of Baton Rouge were filled with migrants. The Golden-winged, Blackburnian, and Canada Warblers were each recorded in the vicinity of Baton Rouge for the first time in the spring. Second spring records were obtained for the Black-billed Cuckoo and for the Black-throated Green Warbler (Table 2). To ornithologists who know these species as abundant spring migrants in the Mississippi valley, their rarity at Baton Rouge must appear inconceivable.

Observations in the spring of 1943 are also illustrative of the rarity of transient migrants at Baton Rouge. My associates and I were in the field 42 of the 47 days between March 20 and May 7. A. W. Burdick,

TABLE 2
SPRING STATUS AT BATON ROUGE OF CERTAIN TRANS-GULF MIGRANTS 1933-1943

	Number of Records ^a
Black-billed Cuckoo, <i>Coccyzus erythrophthalmus</i>	3
Alder Flycatcher, <i>Empidonax traillii</i>	None
Least Flycatcher, <i>Empidonax minimus</i>	None
Philadelphia Vireo, <i>Vireo philadelphicus</i>	None
Golden-winged Warbler, <i>Vermivora chrysoptera</i>	4
Blue-winged Warbler, <i>Vermivora pinus</i>	5
Nashville Warbler, <i>Vermivora ruficapilla</i>	None
Yellow Warbler, <i>Dendroica aestiva</i>	A few yearly
Magnolia Warbler, <i>Dendroica magnolia</i>	9
Cape May Warbler, <i>Dendroica tigrina</i>	None
Black-throated Green Warbler, <i>Dendroica virens</i>	4 ^b
Blackburnian Warbler, <i>Dendroica fusca</i>	3
Chestnut-sided Warbler, <i>Dendroica pensylvanica</i>	6 ^c
Bay-breasted Warbler, <i>Dendroica castanea</i>	6 ^d
Black-poll Warbler, <i>Dendroica striata</i>	3
Oven-bird, <i>Seiurus aurocapillus</i>	4
Northern Water-thrush, <i>Seiurus noveboracensis</i>	1
Canada Warbler, <i>Wilsonia canadensis</i>	2
Scarlet Tanager, <i>Piranga olivacea</i>	5
Rose-breasted Grosbeak, <i>Hedymeles ludovicianus</i>	4

^a One "record" = one or more individuals of a given species seen on one day.

^b One bird for each "record" except on May 1 and 2, 1940, when a number were seen. See text discussion of April 30-May 3, 1940.

^c Three of these were on April 30-May 2, 1940; another was of a bird that struck the State Capitol light on May 17, 1940.

^d Three of these were on April 30-May 2, 1940.

an able field observer who assisted me for several years at Baton Rouge, spent the period of April 22 to May 12 at Memphis, Tennessee, for the express purpose of collecting comparable data. During the whole period, only four species of transient trans-Gulf migrants were found at Baton Rouge, and these were represented by a total of only seven individuals: one Blue-winged Warbler, April 18; two Yellow Warblers, April 24; two Scarlet Tanagers, one on April 16 and one on April 24; two Rose-breasted Grosbeaks, on April 24. From April 18 to 24 and from April 25 to May 7, absolutely no transient trans-Gulf migrants were found. Yet on April 22 at Memphis, Burdick recorded 15 species (13 species of warblers and 2 thrushes) of transient trans-Gulf migrants, and during the period April 22 to May 9, he recorded a total of 26 species of transients. Some were recorded throughout the period, for example, the Olive-backed Thrush (6 to 35 individuals daily), and the Black-poll Warbler (8 to 25 individuals daily). The Nashville Warbler, for which there are no spring records at Baton Rouge, was seen by Burdick from April 22, when he recorded 75 individuals, to May 5. (Cf. Burdick and Tucker, 1943; see also Table 9.)

An occurrence on the night of April 20, 1933, is of particular interest. Between 8:30 and 9:00 P.M. a thunder storm accompanied by considerable hail occurred at Baton Rouge. The resulting damage to local bird life has been described by Gates (1933). Twenty-seven Scarlet Tanagers were found dead or injured on or near the University campus on the morning following the storm. Since these 27 birds probably represent only a fraction of those actually killed, it is likely that a considerable flight of the species was migrating over Baton Rouge on this night. The date, April 20 (1933), stood for 10 years as the earliest spring "arrival date" for the Scarlet Tanager at Baton Rouge (until April 16, 1943, when a single individual was seen), and the species was noted on only four occasions in the interim. Hence, here is a species that has been noted an aggregate of only five times in 10 years at Baton Rouge; yet it is definitely a trans-Gulf migrant, and there is evidence that on April 20, 1933, a considerable number were passing over Baton Rouge.

AVERAGE ARRIVAL DATES

Because the appearance of transient trans-Gulf migrants at any particular locality in the lower Mississippi valley is dependent largely on specific weather phenomena, arrival dates are highly variable. Ornithologists in other sections of the United States may find it useful to compute average arrival dates for each migrant species, but it is apparent from the foregoing statements that in the Gulf coast region average arrival dates are of little or no significance. The "average" date so computed is not the usual arrival date of the species in question (that is, the

date on which they begin passing over the area) but is in general the average date on which polar-front weather has precipitated birds in that particular area.

EARLIEST ARRIVAL DATES

The recording of the initial appearance of a species in a given area in any particular year is admittedly a highly fortuitous matter. But in regions where there are a number of observers in the field almost daily over many consecutive years, the "earliest date of arrival" of a species assumes considerable significance. Although the rate of advance up the Mississippi valley may be variable from year to year, depending on a number of factors such as the variable rate of the "advance of spring" up the valley (Cooke, 1888:37-41), the dates of arrival of trans-Gulf migrants that breed along the Gulf coast and elsewhere in the extreme lower Mississippi valley are remarkably uniform from year to year, and the earliest dates of their arrival there are consistently in advance of the arrival of the same species several hundred miles up the Mississippi valley—which is exactly what one would expect.

Dates of arrival on the Gulf coast of *transient* trans-Gulf migrants are, on the other hand, highly variable, and many species are recorded consistently much earlier in Tennessee, for example, than on the coast itself. If these transients regularly descended on reaching land, one would expect the "first arrival" dates along the coast to be earlier than those recorded farther inland.

In Table 3, 24 species of birds that do not breed in the lower Mississippi valley but are known to be trans-Gulf migrants in the spring are listed with the earliest dates on which they have been recorded in several regions. The earliest dates of arrival at Memphis, over 300 miles north of the Gulf coast, are in many instances earlier than those recorded at Pensacola, on the coast of Mississippi, or at Baton Rouge. Fifteen (63 per cent) of the species listed in Table 3 have been recorded earlier at Memphis than they have at Baton Rouge. Ten have been detected at Memphis earlier than on the coast of Mississippi, and the same number have been seen earlier at Memphis than at Pensacola. Similarly, Nashville records are in some instances earlier than those recorded at certain Gulf coast stations. Six (25 per cent) of the species listed have been recorded earlier either at Memphis or Nashville than at Pensacola, on the coast of Mississippi, or at any locality on the coast of Louisiana. These figures are significantly high when one considers the long period of years over which Gulf coast records have been kept and the greater number of ornithologists who have studied there compared with the number who have made observations at the two Tennessee stations. This consistently earlier recording of transients in Tennessee can be explained only if incoming migrants as a rule (i.e., during fine weather) pass over the Gulf coast in the spring and proceed far inland before descending.

TABLE 3
EARLIEST ARRIVAL DATES FOR CERTAIN TRANSIENT MIGRANTS IN VARIOUS SOUTHERN REGIONS *

Species	Coastal Louisiana (misc.) 1885-1944	Coastal Mississippi 1935-43	Pensacola, Florida 1916-43	Baton Rouge, Louisiana 1933-44	Memphis, Tennessee 1926-43	Nashville, Tennessee 1915-43	Athens, Georgia 1921-35
Black-billed Cuckoo (<i>Coccyzus erythrophthalmus</i>)	April 11	May 5	May 2	April 21	April 28	May 3	April 27
Yellow-bellied Flycatcher (<i>Empidonax flaviventris</i>)	May 12	May 12	no spring record	no spring record	May 11	no spring record	no spring record
Olive-backed Thrush (<i>Hylocichla ustulata</i>)	April 19	April 19	April 5	April 20	April 11	April 16	April 10
Gray-cheeked Thrush (<i>Hylocichla minima</i>)	April 20	April 12	no spring record	April 22	April 23	April 8	May 20
Veery (<i>Hylocichla fuscescens</i>)	April 20	April 20	April 15	April 20	April 20	April 24	April 19
Philadelphia Vireo (<i>Vireo philadelphicus</i>)	April 26	May 7	April 18	no spring record	May 2	April 28	no spring record
Golden-winged Warbler (<i>Vermivora chrysoparia</i>)	April 6	April 10	April 5	April 17	April 13	April 26	April 26
Blue-winged Warbler (<i>Vermivora pinus</i>)	March 22	March 27	April 4	April 12	April 3	April 7	April 16
Tennessee Warbler (<i>Vermivora peregrina</i>)	March 28	April 7	April 12	April 6	April 9	April 21	May 1
Nashville Warbler (<i>Vermivora ruficapilla</i>)	April 11	no spring record	no spring record	no spring record	April 16	April 22	no spring record
Magnolia Warbler (<i>Dendroica magnolia</i>)	April 20	April 19	April 27	April 17	April 21	April 18	April 15
Cape May Warbler (<i>Dendroica tigrina</i>)	April 27	May 1	no spring record	no spring record	April 27	April 16	April 14
Black-throated Blue Warbler (<i>Dendroica caerulescens</i>)	March 22	April 30	no spring record	no spring record	May 5	April 21	April 7

TABLE 3 (Continued)

Species	Coastal Louisiana (misc.) 1885-1944	Coastal Mississippi 1935-43	Pensacola, Florida 1916-43	Baton Rouge, Louisiana 1933-44	Memphis, Tennessee 1926-43	Nashville, Tennessee 1915-43	Athens, Georgia 1921-35
Black-throated Green Warbler (<i>Dendroica virens</i>)	April 8	March 24	March 20	May 1	March 19	March 20	March 24
Blackburnian Warbler (<i>Dendroica fusca</i>)	March 27	March 27	April 5	April 26	April 5	April 7	March 29
Chestnut-sided Warbler (<i>Dendroica pensylvanica</i>)	March 21 (winter?)	April 14	April 12	April 16	April 16	April 22	April 20
Bay-breasted Warbler (<i>Dendroica castanea</i>)	April 17	April 19	April 24	April 17	April 22	April 19	April 26
Black-poll Warbler (<i>Dendroica striata</i>)	April 15	April 26	April 23	April 25	April 21	April 18	April 19
Oven-bird (<i>Seiurus aurocapillus</i>)	March 28	March 31	April 4	April 21	April 11	April 1	April 3
Northern Water-thrush (<i>Seiurus noneboracensis</i>)	April 6	April 19	April 5	April 16	April 19	?	April 15
Canada Warbler (<i>Wilsonia canadensis</i>)	no spring record	May 10	no spring record	May 1	April 24	April 28	April 27
Bobolink (<i>Dolichonyx oryzivorus</i>)	April 1	April 30	April 20	April 19	April 28	April 19	April 14
Scarlet Tanager (<i>Piranga olivacea</i>)	April 3	April 3	April 5	April 15	April 16	April 6	April 11
Rose-breasted Grosbeak (<i>Hedymeles ludovicianus</i>)	April 16	April 15	April 21	April 21	April 18	April 18	April 22

* Data in this table have been drawn from the following sources: *Louisiana localities*—From Oberholser (1938), from records and specimens in the Louisiana State University Museum of Zoology, and from records and specimens assembled by Thomas D. Burleigh and Thomas R. Howell at New Orleans; the term "Coastal Louisiana" refers to the combined records from New Orleans, Grand Isle, and Camerón. *Coastal Mississippi*—Burleigh (1944). *Pensacola, Florida*—From records and specimens assembled by Francis M. Weston. *Athens, Georgia*—Burleigh (1938). *Memphis, Tennessee*—Records assembled by Ben B. Coffey and his associates and from specimens collected by Eugene Wallace, Austin W. Burdick, and Robert Tucker and deposited in the L.S.U.M.Z. *Nashville, Tennessee*—From records and specimens assembled by Albert F. Ganier and his associates.

EXTENT OF THE COASTAL HIATUS

There is considerable evidence that the "coastal hiatus" in Mississippi valley migration extends northward across the entire Gulf coast region well beyond the 31st parallel of latitude. Just how far inland the hiatus extends requires much additional investigation, but the most southern locality in the Mississippi valley with a "normal" spring migration seems to be Memphis, Tennessee (Map 1). There are minor fluctuations discernible in the flow of migrants in this region, but for the most part, the place throngs day after day with migrants. Many of the species listed in Table 2 as rare or absent in spring at Baton Rouge are very common in migration at Memphis. Hence the northern edge of the hiatus must lie to the south of Tennessee.

Further investigation will probably show that the relative abundance of migrants increases in direct proportion to the distance from the coast. During the period 1929 to 1932, I observed birds at Monroe and Ruston in northern Louisiana; between 1932 and 1943, I received many valuable notes from the late Mrs. George H. Lowery, Sr., who lived at Monroe and made a study of the bird life in that vicinity. Although there is need for much additional field work in northern Louisiana, it can be said that spring migration at Monroe is far more pronounced than at Baton Rouge, but probably appreciably less than at Memphis. Nearly all of the trans-Gulf migrants are seen regularly in spring at Monroe, yet their numbers do not seem to approach those recorded slightly farther north, at Memphis. Burleigh's careful and intensive survey of the bird life at Athens, Georgia (1938), likewise shows that fewer migrants are seen at that locality than slightly farther north in the lower Allegheny Mountains (Pearson, Brimley, and Brimley, 1942).

Speculation on the destination of the Scarlet Tanagers prior to encountering the hail storm at Baton Rouge (see above) gives some indication of the extent of the coastal hiatus. Assuming that the tanagers had continued flying at a minimum speed of 25 m.p.h., they could have covered a distance of approximately 250 miles and reached southern Arkansas or northern Mississippi by daybreak.

There is, of course, no way of knowing whether the tanagers had only recently departed, during the preceding late afternoon; from some coastal region, en route northward via Baton Rouge, or whether, on the contrary, they were still in continuous flight from some tropical locality. The time of their passing Baton Rouge, about two hours after sunset, suggests the former inference, since it would require just about that length of time for the birds to reach Baton Rouge from almost any Gulf coast point.

But regardless of whether this particular flight of tanagers had its beginning in tropical America or on the Gulf coast of Louisiana, the significant feature of the coastal hiatus is again illustrated: Migrants which arrive on the northern Gulf coast during favorable weather con-

tinue inland a considerable distance and hence miss the greater part of the Gulf coast region. Migrants which arrive on the northern Gulf coast during unfavorable weather are precipitated in the coastal areas, but as the weather clears, they resume their flight, the initial part of which again carries them over vast stretches of the Gulf coast states.

TRANS-GULF MIGRANTS THAT BREED IN THE LOWER
MISSISSIPPI VALLEY

Discussion up to this point has been concerned wholly with transient trans-Gulf migrants, i.e., species that do not breed along the Gulf coast or in the extreme lower Mississippi valley. Whereas transient migrants are decidedly rare⁵ and arrive irregularly throughout interior Louisiana, Mississippi, and other southern states, migrants which stop to breed arrive on their breeding grounds with remarkable regularity.

The Prairie Warbler (*Dendroica discolor*) is a case in point. During the past 10 years, the species has been recorded only once within the immediate environs of Baton Rouge, where it does not breed. However, it does breed abundantly 20 miles northeast of Baton Rouge near Baywood in the cut-over pine-hardwood region, and it appears regularly there on or around April 1. In view of the abundance of the species just beyond Baton Rouge we might surmise that it would be at least fairly common in migration at the latter place. Such is not the case. The single Baton Rouge record is an individual seen on April 21 (1940), nearly three weeks later than the species regularly appears at Baywood. Similarly, the Worm-eating Warbler (*Helmitheros vermivorus*) breeds fairly commonly in the wooded beech-magnolia ravines of West Feliciana Parish, but has not yet been recorded in the spring 30 miles south at Baton Rouge.

At Baton Rouge such common nesting species as the Parula, Yellow-throated, Swainson's, Prothonotary, Kentucky, and Hooded Warblers, the Chat, the Warbling Vireo, Red-eyed, and Yellow-throated Vireos, Orchard and Baltimore Orioles, Acadian Flycatcher, Wood Pewee, Eastern Kingbird, Nighthawk, Chuck-will's-widow, Yellow-billed Cuckoo, Summer Tanager, Purple Martin, Painted and Indigo Buntings, and others, arrive on dates that are comparable with arrival dates at other Gulf coast stations where the species also breed.

Analysis of the status of certain species at Baton Rouge, Pensacola, Gulfport, and New Orleans shows clearly the difference between the arrival of birds in areas where they are known to breed and in areas where they are strictly transient. For example, Swainson's Warbler (*Limnothlypis swainsonii*) breeds commonly at Baton Rouge and at New Orleans, but not at Gulfport nor at Pensacola. The species arrives regularly at Baton Rouge on or shortly after April 2 and has been noted as early as March 30 at New Orleans. At Pensacola, where Swainson's

⁵ This, of course, leaves out of consideration herons, swallows, and other birds that are, in part, coastwise migrants.

Warbler does not breed, it has not yet been recorded during spring migration. Yet the species is known to breed a short distance north of Pensacola (Weston, *in litt.*), and just east of Pensacola at Whitfield (Howell, 1932), where Worthington and Todd (1926:223) took 20 specimens between April 4 and May 1, 1903.

Further, Swainson's Warbler breeds at Brooklyn, Mississippi (Burleigh, *in litt.*), and at New Orleans, places which are respectively 50 miles north and 50 miles west of Gulfport. Nevertheless, in the eight years of his intensive field work at Gulfport, Burleigh has observed the species but once in the spring. This was an individual seen on April 19, 1943. The following quotation is taken from Burleigh's field notes for that date: "Weather clear with strong, cold, northwest wind [typical polar-front weather]. Island alive with birds for the first time this year" (Table 9). Burleigh, on the same day, procured his earliest Gulfport record for the Bay-breasted Warbler (*Dendroica castanea*) and the Northern Water-thrush, the former being six days earlier than his earliest previous record for the spring. The principal conclusions to be drawn from these data are: Swainson's Warbler is common after April 1 at localities on the Gulf coast where it nests; in areas where it does not nest, it is rare or absent in the spring; and when it does occur in such areas, its appearance there is correlated with a general precipitation of transients as a result of unfavorable weather conditions.

The situation with respect to the Dickcissel (*Spiza americana*) is similar to that of Swainson's Warbler, for the species does not breed at either Pensacola or Gulfport, but does breed locally at Baton Rouge and at New Orleans. At the two latter places it arrives regularly by April 15 and is often abundant by April 20. There are, however, no spring records for Gulfport, and Weston has seen the species but once at Pensacola in 28 years.

THE COASTAL HIATUS AND MAPS OF MIGRATION ROUTES

The absence of records for a given species from all coastal stations during prolonged periods of study must by no means be taken as proof that the species in question is not a trans-Gulf migrant. Given the right kind of weather and a competent observer at exactly the right spot, species which have previously gone undetected at coastal stations may finally be recorded in great numbers.

For example, up to 1942 there were no spring records for the Nashville Warbler from southern Louisiana, Mississippi, Alabama, or western Florida. But between April 9 and 11, 1942, at Cameron, Louisiana, the Nashville Warbler was found in considerable numbers among the swarms of migrants that were precipitated on the coastal ridges by polar-front weather on April 9 and 10. The following excerpts are taken from my field notes: "April 9: Strong north winds attended by very cloudy and unsettled weather . . . April 10: Skies cleared about noon,

but wind continued out of the north throughout the remainder of the day and part of that night . . . Collected two nighthawks from a small flock feeding low over the edge of marsh at dusk, and both, much to our amazement, proved to be the Texas Nighthawk (*Chordeiles acutipennis*). This is the first Louisiana record and a considerable eastward extension of range . . . April 11: Plenty of migrants of all kinds on the narrow, wooded cheniers . . . Secured third Texas Nighthawk . . . Concentrations of birds noted today are precisely what we expected in view of the weather. Migrants coming across the Gulf in the face of the north wind dropped down upon the first bit of land instead of passing on inland . . . Warblers found in virtually every bush. Probably as many as several thousand warblers alone seen in course of day. These consisted of 26 species, the most surprising being the Nashville Warbler, which was present in considerable numbers" (Table 7). In all probability the Nashville Warbler will eventually be found in comparable numbers at other Gulf coast stations when a weather barrier occurs at the given locality at the precise time that a flight of Nashville Warblers reaches that point.

Similarly, the Philadelphia Vireo had not been recorded in spring at any coastal station before April 18 and 19, 1919, when Weston saw one at Pensacola. It has since been recorded on the coast only from Gulfport (one collected by Burleigh on May 7, 1941) and from Cameron (three collected by Sutton and Lowery on April 26 and 30, 1942). Thus the absence of the Philadelphia Vireo from most Gulf coast regions is by no means an indication that the species is not a regular trans-Gulf migrant. Since during favorable weather all transient trans-Gulf migrants fly far inland before descending, the Philadelphia Vireo can be expected at any coastal station only when forced down by adverse weather conditions.

The Warbling Vireo (*Vireo gilvus*) is a further case in point. The species breeds at certain localities within the coastal hiatus but not on the coast itself. In those localities where it does not breed, it has the status of other transient trans-Gulf migrants, i.e., it is absent entirely, rare, or highly intermittent in occurrence. The Warbling Vireo does not breed at Pensacola, Gulfport, or Cameron, and it has been recorded at none of these localities in the spring. At localities within the coastal hiatus where the species breeds, it has the status of all species of locally breeding trans-Gulf migrants, i.e., it is regular in appearance. At Baton Rouge, for example, where the Warbling Vireo breeds, it arrives regularly on or about March 26.

Wilson's Warbler (*Wilsonia pusilla*) has not been noted in spring from any locality in the South that lies east of Texas and less than 150 miles from the coast. However, the species reaches localities in northern Georgia and North Carolina on dates almost simultaneous with its arrival in the middle Mississippi valley. The great number of individuals that migrate northward parallel to the Allegheny Mountains must,

therefore, as Cooke concluded 40 years ago (1904:127-128), jump over the southern part of the Mississippi valley and the Gulf of Mexico from their winter home in southeastern Mexico.

The Connecticut Warbler (*Oporornis agilis*) is generally supposed to migrate northward through the Florida Peninsula, and the Mourning Warbler (*Oporornis philadelphia*) is supposed to migrate northward by way of eastern Mexico and the Texas coast (Map 2). They are said to converge in the middle Mississippi valley (Cooke, 1904 and 1915; Lincoln, 1935 and 1939; Wetmore, 1926; Chapman, 1932; and others). Practically every writer on bird migration cites the Connecticut Warbler as an example of a species that reaches the United States exclusively by way of the Florida Peninsula. In fact, no alternative route appears to have been proposed. Let us examine the true status of the species in



Map 2. The commonly accepted spring migration routes (shaded areas) of (1) the Mourning Warbler (after Chapman), and (2) the Connecticut Warbler (after Lincoln and others). The winter range (in part) of the Mourning Warbler is shown in black. The migration routes postulated in this paper are indicated by the dotted lines.

Florida. Howell (1932) describes it as "a rare migrant in spring and fall." Citing presumably all authentic records for the state, he gives records for only five localities where the bird has been seen in spring, two of which are lighthouses. In the West Indies, the species has been recorded only from the Bahama Islands (Bond, 1936 and 1940). On the other hand, the Mourning Warbler which most, if not all, writers describe as reaching the United States by way of eastern Mexico and the coast of southern Texas, has been recorded three times from Florida (Howell, 1932); two of these records were in the spring. Frazar (1881: 251) saw "large numbers" of Mourning Warblers in migration 30 miles south of the mouth of the Mississippi River on April 22, 1881.⁶

There is additional ground for assuming that the Connecticut and Mourning Warblers are at least in part trans-Gulf migrants. Both have been noted in the spring in northern Louisiana, and both are fairly regular in their occurrence at Memphis, Tennessee, localities which are rather far to the west unless a more direct trans-Gulf flight is admitted. Furthermore, Sutton (1938) reports the taking of a male specimen of the Connecticut Warbler in western Oklahoma on May 18, 1937. This record is after all not so surprising when we recall that the species breeds as far west as Alberta. The earliest spring records for the Connecticut Warbler in northern Louisiana, at Memphis, and at Nashville (April 27, 27, and 21, respectively) are earlier than Burleigh's earliest record (May 7) for the species at Athens, Georgia (Burleigh, 1938). On the basis of the alleged "Florida flyway," Athens should get the vanguard of the migrants.

An additional point of considerable importance is the fact that the Connecticut and Mourning Warblers are late migrants. The earliest Florida record for the Connecticut Warbler is May 4, and the bulk of the records for that state are past the middle of May. In this latitude, distinct polar-front weather is less prevalent during May than during April, and hence species which migrate in late May are much less likely to be precipitated on the coast by local weather phenomena than are species which migrate during April. The absence of eastern Gulf coast records for the Connecticut Warbler is therefore not nearly so surprising as the lack of spring records for the Gray-cheeked Thrush and the Swainson's, Golden-winged, and Nashville Warblers at Pensacola, or the absence of spring records for the Warbling Vireo, Dickcissel, and Nashville Warbler at Gulfport. Various other birds that are far better known and in some cases much more easily detected than either the Mourning or the Connecticut Warblers have been recorded at none of the Gulf coast stations for many years, and yet no circuitous routes of migration have been proposed for them. It is thus apparent that undue emphasis has been placed on the absence of records for the Mourning and Connecticut Warblers in the lower Mississippi valley and along the Gulf

⁶ See Note 2, p. 95.

coast. This hiatus in the spring "occurrence" of these species represents, in all probability, nothing more than the area over which trans-Gulf migrants habitually pass before descending.

WEATHER AND MIGRATION WAVES

Through the courtesy of Mexican weather authorities, I obtained limited but valuable information pertaining to the state of the weather on the Yucatan Peninsula and in the region bordering the Bay of Campeche on days (1939-1943) when certain weather phenomena are known to have occurred in the northern Gulf coast region (U. S. Weather Bureau, 1933-1943). A few of these cases are analyzed in Tables 4 to 9.

Many migrant North American birds are known to pass northward overland through Central America into southeastern Mexico, whence they depart for the United States via the trans-Gulf flyway. We can assume with fair certainty that, should clear weather prevail in the Yucatan-Campeche region, north-bound migrants would not accumulate there; that is, upon reaching the Bay of Campeche or the northern part of the Yucatan Peninsula, migrants would proceed directly across the Gulf.⁷ So long as favorable conditions prevailed in both the Yucatan and Gulf coast regions, the steady flow of trans-Gulf migrants would continue far inland and descend over a comparatively wide area in the middle Mississippi valley. The hundreds of thousands of birds that stream across the Gulf flyway, even though dispersing widely upon alighting, insure any interior station, if far enough inland, a more or less smooth stream of north-bound migrants. But north Gulf coast regions would be almost, if not wholly, without transient migrants.

⁷ An inferential basis for this assumption is supplied by our knowledge of what south-bound migrants do on the northern Gulf coast in fall prior to undertaking their return flight across the Gulf. Although the fall migration is known to be less hurried than the spring, migrants do not tend, as a general rule, to accumulate along the coast unless there are strong winds from the south. The subject of fall migration in this region will be discussed in detail in a later paper.

TABLE 4
THE WEATHER AND MIGRATION, MARCH 1-4, 1939

1939 March	Yucatan Peninsula	Gulfport, Mississippi	
	Weather	Weather	Migrants
1-3	Clear; SE wind	Cloudy; slight rains; S wind	None
4	[no data]	Polar-front weather: rains; NW wind	Large number of early migrants

[Interpretation: Between March 1 and 3 migrants leave Yucatan region under favorable weather conditions. Since they encounter favorable weather on reaching the northern Gulf coast, they continue northward over the coast, and no migrants are recorded there. On March 4 incoming migrants encounter head winds associated with advancing polar fronts and are precipitated on the first available land.]

TABLE 5
THE WEATHER AND MIGRATION, APRIL 23-MAY 4, 1940

1940 April	Yucatan Peninsula	Gulfport, Mississippi		Baton Rouge, Louisiana	
	Weather	Weather	Migrants	Weather	Migrants
23-24	Slight SE wind	Partly cloudy; S wind	Small number	Partly cloudy; SW wind	None
25	Same	Heavy overcast; rain; S wind	Small number	Partly cloudy; slight rain; vari- able NE wind	None
26	Same	Polar-front wea- ther: cloudy; heavy rains; N wind	Record num- ber	Clear; E wind	None

[Interpretation: Migrants, leaving Yucatan region under favorable conditions, at first encounter favorable weather north of the Gulf and continue inland, passing over the northern Gulf coast region as well as the middle region (represented by Baton Rouge). On April 26, however, migrants are precipitated by polar-front weather at Gulfport (and presumably elsewhere along the part of the coast covered by the polar front).]

27	Light showers on E coast; SE wind	Clear; S wind	Almost none	Cloudy; SE and E wind	[no data]
28	Slight SE wind	Partly cloudy; S wind	None	Cloudy; SE wind	Almost none
29	Same	Partly cloudy; showers; S wind	None	Polar-front wea- ther: heavy over- cast; variable winds; 2.44 in. rain; electrical storm	Moderate number
30	Same	Polar-front wea- ther: heavy over- cast; heavy rain; strong S wind shifting to N	Moderate number	Continued polar- front weather	Large number

[Interpretation: Migrants precipitated on the coast on April 26 leave on April 27 and 28, when the weather clears, and pass over the middle region, where the weather continues fair. Since favorable conditions still prevail in the Yucatan region, the northward flow of migrants continues, and these pass over the coast as well as over the middle region until April 29, when polar-front weather precipitates migrants at Baton Rouge (and presumably along the entire polar front). The polar front moves south-eastward, and on April 30, migrants are again precipitated at Gulfport.]

May 1	Slight N wind	Continued polar- front weather: heavy rains; NW wind	Record num- ber (notably on coastal is- lands)	Cloudy in fore- noon; N wind. Clear later; SW wind	Record number
2	SE wind	Clear; N wind	Almost none	Clear; W wind	Record number
3	Same	Clear; N wind	Almost none	Clear; NW wind	Moderate number
4	Same	Clear	Almost none	Clear; SW wind	Almost none

[Interpretation: North wind over the Yucatan Peninsula on May 1 retards departure of migrants; hence, though a north wind prevails on the northern Gulf coast on May 2, there are few or no incoming migrants to be precipitated.]

TABLE 6
THE WEATHER AND MIGRATION, MARCH 25-29, 1942

1942 March	Yucatan Peninsula	Grand Isle, Louisiana	
	Weather	Weather	Migrants
25	Dry; SE wind	Cloudy; S wind	[no data]
26	Same	Same	[no data]
27	General showers; SE wind	Polar-front weather: heavy overcast; strong N wind	Large number
28	General showers; strong N wind	Skies clear; wind shift- ing from N	Record number
29	[no data]	Clear; S wind	Moderate number (ap- parently no new ar- rivals)

[Interpretation: Migrants leaving Yucatan region on March 25 encounter favorable weather on the northern Gulf coast, but those leaving on March 26 and 27 are precipitated in coastal areas by an advancing polar front.]

[Interpretation: Presumably almost no migrants leave the Yucatan region on March 28 in face of strong N wind and other polar-front phenomena, and hence no new arrivals are detected on the northern Gulf coast on March 29. Favorable weather in the Grand Isle region on March 29 permits resumption of northward flight by birds precipitated there on the two preceding days.]

TABLE 7
THE WEATHER AND MIGRATION, APRIL 7-11, 1942

1942 April	Yucatan Peninsula	Cameron, Louisiana	
	Weather	Weather	Migrants
7-8	SE wind	Cloudy; heavy rains; strong, variable S wind	[no data]
9	Scattered showers; SE wind	Polar-front weather: heavy rains; N wind	Record number
10	General rains; N wind	Continued polar-front weather	Record number increas- ed by new arrivals
11	N wind	Skies clear; tempera- ture rises; wind shifts to S	Record number

[Interpretation: The stream of migrants leaving the Yucatan region under favorable weather conditions is not interrupted until at least April 10. Encountering polar-front weather, the migrants are precipitated on the northern Gulf coast on April 9 and continue to accumulate there on April 10. The tremendous numbers recorded at Cameron on April 11 possibly included arrivals on that day, but it is probable that the change in weather in the Yucatan region stopped the stream of departing migrants on April 10.]

TABLE 8
THE WEATHER AND MIGRATION, MAY 5-9, 1942

1942 May	Yucatan Peninsula	Gulfport, Mississippi	
	Weather	Weather	Migrants
5	Clear to slightly cloudy; SE wind	Clear; warm; S wind	None
6	Same	Cloudy; S wind	None
7	Same	Polar-front weather: rain; N wind	Large number
8	Rain on E coast and in N; N wind	Skies clear; S wind	Small number
9	[no data]	Clear; warm; S wind	Almost none

[Interpretation: Migrants leaving Yucatan under favorable conditions on May 5 and 6 encounter similar conditions on northern Gulf coast and consequently pass inland over the coast before descending. On May 7 incoming migrants are precipitated by a polar front that advances to the Gulf coast on that date. Effects of polar front extend to Yucatan region on May 8 and stop the northward flow of migrants; at the same time fine weather on the northern Gulf coast causes the migrants precipitated on May 7 to resume their flight northward; and the region is then almost without migrants.]

TABLE 9
THE WEATHER AND MIGRATION, APRIL 14-20, 1943

1943 April	Yucatan Peninsula	Gulfport, Mississippi	
	Weather	Weather	Migrants
14-15	Cloudy; scattered showers; N wind	Cloudy; S wind	None
16	Cloudy; SE wind	Cloudy; intermittent rain; strong SE wind	One
17	Same	Same	Small number
18	Same	Same, but more unsettled	Moderate number
19	General rains, heavy on E coast; strong NW wind	Polar-front weather: heavy rains; strong NW wind	Record number
20	[no data]	Clear; cold; wind shifting to S	Small number

[Interpretation: On April 14 and 15 weather conditions prevent departure of migrants from the Yucatan region. At least some migrants leave on April 16 and 17 with the improved weather, and a few are precipitated on the Gulf coast on April 17. (Since the weather is semi-favorable along the coast, some migrants may proceed inland.) As the weather becomes more unfavorable, increasing numbers pile up on the coast until April 20, when there are no new arrivals because unfavorable weather in the Yucatan region has again prevented departure of migrants, and favorable weather on the northern Gulf coast permits the accumulated migrants there to resume their northward flight, thus emptying the region of its migrant bird life.]

Thus, with clear weather in both the Yucatan-Campeche and the Gulf coast regions, one may walk the length of Grand Isle, or search the woods about Baton Rouge or any other locality in the extreme lower Mississippi valley region, and not find a single transient migrant. This has been done time and again by all Gulf coast observers—not just for one day, but day after day so long as fine weather prevails.

Now let us assume that a polar front advances from the north and reaches the Gulf coast. The coastal islands and other coastal regions are then flooded with migrants. The migrants behind the polar front drift on northward. If the weather clears rapidly, the migrants retarded along the coast by the weather barrier leave almost simultaneously, and their first flight carries them far inland, over an extensive area of the coastal region. Ornithologists in the general area in which the major part of the flight finally descends record the appearance of a "wave."

On the other hand, let us suppose a period of inclement weather in the Yucatan-Campeche region. Just as south-bound migrants tend to accumulate on the northern Gulf coast in the fall in the face of bad weather, so, presumably the north-bound migrants accumulate in the Yucatan-Campeche area in the spring. This results in not only a large assemblage of individuals, but also a wide variety of species. Assuming that on the advent of clear weather a considerable part of the accumulated hordes start across the Gulf almost simultaneously, it is apparent that some section of the Mississippi valley region will shortly receive a large and diversified wave of migrants. Since, during the preceding days of bad weather, no migrants have crossed the Gulf, and since birds which crossed ahead of the bad weather have progressed far northward during the lull, the resumption of even the usual flow of migrants across the Gulf would produce a distinct wave; but this particular flight will contain not only the migrants of the usual steady stream, but also those which have accumulated during the bad weather in the Yucatan region. If, then, this flight encounters a new polar front as it crosses the Gulf, the precipitation on the northern Gulf coast will greatly exceed the precipitation resulting from the stopping of just the daily clear-weather flow of migrants.

This alternate passing over or dropping down of migrants that is recorded in the Gulf regions breaks up what would otherwise be a steady flowing stream of migrants, and waves of migrants result. There seems to be little doubt that this is an important factor contributing to the wave characteristic of northward migration which many writers have noted. The great fluctuations discernible in the southern states must extend in their effects considerable distances up the Mississippi valley and possibly throughout the eastern United States. However, the stupendous number of migrants moving up the valley would seem to have a tendency to produce a smoothing-out effect on the flow of migrants. As far north as Memphis, for instance, there is a more or less continuous stream of migrants, with only minor interruptions.

Of course, as birds progress up the valley, weather conditions might tend to retard migrants in this or that region, and new waves might result. However, waves in the upper Mississippi valley are apparently not comparable in intensity with waves on the Gulf coast. I have seen no account from northern regions which reports a complete absence of migrants once the spring procession has begun.

GEOLOGICAL CONSIDERATIONS

Ornithologists in general agree that the basic pattern of bird migration is closely correlated with Pleistocene or Ice Age history. Specific events in the Pleistocene history of the Gulf coast may or may not have a direct bearing on the present-day Gulf coast hiatus in migration, but they constitute a very interesting basis for cautious speculation.

The land bordering the Gulf of Mexico was by no means stable or fixed during late geologic time; it was, on the contrary, subject to frequent and radical alteration, a fact which must have had more than a minor influence on the pattern of trans-Gulf migration.

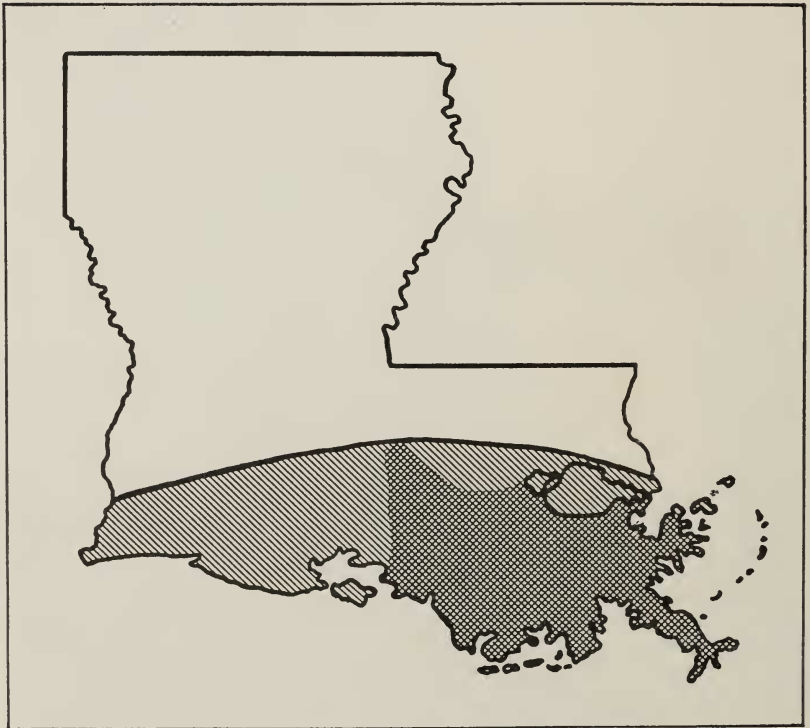
During the major glacial stages of the Pleistocene, the seas were lowered approximately 400 feet as a result of evaporation and subse-



Map 3. The Gulf coast. Dotted areas show the approximate extension of the coast during the maximal lowering of the seas in the major glacial stages of the Pleistocene. (Based on the 400-foot contour of bathometric charts.)

quent deposition of moisture as land-covering ice. This lowering of the seas effected great changes in the size and shape of the Gulf of Mexico and the adjacent land. Plotting the 400-foot contour of the Gulf, as is done in Map 3, presents a fairly accurate picture of the shore line of the Gulf during the maximum ice advance in each of the glacial stages. Florida, for instance, was in some places about twice as broad as it is today; southwestern Louisiana extended some 100 miles beyond its present limits; and the Yucatan Peninsula extended farther northward. That is, at the time that northern birds were being forced into the south, the Gulf was a much smaller body of water and hence much easier to cross.

During the interglacial stages, the melting ice of the retreating glaciers slowly refilled the seas, and it is possible that on occasions the level of the sea was somewhat higher than it is at the present day. Following the last, or Wisconsin, Glacial stage, the level of the Gulf rose rapidly for a period until the Gulf extended a considerable distance up



Map 4. Louisiana. Hatched area shows the approximate encroachment of the Gulf of Mexico during the interglacial stages of the Pleistocene. Cross-hatching represents the "Mississippi Embayment" which occurred about 7,000 years ago.

what is now the Mississippi delta region, reaching a point almost as far north as Baton Rouge (Map 4). Thus a considerable part of the "coastal hiatus" area was at times under water.

SUMMARY

In the spring, during favorable weather, trans-Gulf migrants that do not breed in the Gulf coast region or in the lower Mississippi valley do not come down immediately on reaching land but fly far inland before descending.

During unfavorable weather, incoming migrants of all types are precipitated, sometimes in tremendous concentrations, on the first available land. They pile up on coastal islands and cheniers, at times even in coastal marshes and other unfavorable places.

Migrants which are forced by weather to stop on the shores of the Gulf coast resume their northward flight with the first favorable weather and pass over a vast area of the southern United States before again descending.

Since, depending on the state of the weather, incoming migrants either fly far inland or descend on the very edge of the Gulf coast, the intermediate area becomes an extensive "hiatus" in the path of the trans-Gulf flyway. Within this area, transient migrants are extremely rare, highly intermittent in their occurrence, or even wholly absent during many consecutive spring migrations.

The lack of spring records from the Gulf coast and the lower Mississippi valley for certain species is shown to be an insufficient basis for assuming that they are not trans-Gulf migrants.

Trans-Gulf migrants that breed in the Gulf coast region and in the lower Mississippi valley are regular in their arrival at their breeding grounds, although they may be rare or absent at places a few miles away.

Analysis of weather conditions in the Yucatan-Campeche region preceding specific dates on which migrants are known to have been precipitated on the coast of the United States because of weather barriers reveals that, in all cases examined, birds left the Yucatan-Campeche region under auspicious conditions. For those periods when unfavorable weather is known to have extended across the Gulf to the Yucatan-Campeche region, the available evidence shows that the northward flow of trans-Gulf migrants was stopped, only to be resumed, and in increased magnitude, when the weather permitted.

The data indicate that the "waves" characteristic of spring migration in the Mississippi valley are caused primarily by two factors, both dependent on weather conditions: the alternate passing over or dropping down of migrants that is recorded in the Gulf regions; and the recurrent interruptions of the stream of migrants leaving the Yucatan-Campeche region.